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A STUDY ON AGRONOMIC AND SOIL PARAMETERS TO DEVELOP A WALK BEHIND ENGINE OPERATED WEEDER FOR UPLAND CROPS

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ABSTRACT

Weed control is a major problem in Indian agriculture and needs intensive efforts to mechanize the weeding operation. Weeds are serious threat to all crops. Weeding is an important but equally labour intensive agricultural operation. Delay and negligence in weeding operation affect the crop yield and in many cases cause complete crop failure. A study was conducted in farmer's field at Tondamattur village of Coimbatore district, to study agronomic and soil parameters influencing development of walk behind engine operated weeder. The spacing of okra crop varied from 360 to 400 mm with an average value of 384 mm. Plant height of okra at15 DAS varied from 45 to 55 mm with an average value of 49 mm. The major weeds identified in the field were Acalypha indica, Echinochloa crus-galli, Echinochloa colona and Trianthema protulacastrum. The average pulling force of the weeds was observed to be 0.805, 1.036, 2.137 and 2.217 kgf for the identified weeds respectively. Moisture content of the soil was in the range 13 to 23.4 per cent (db) with an average value of 16.37 per cent (db). The bulk density of the soil was observed to be in the range of 1.08 to 1.56 g cm^{-3} with an average value of 1.348 g cm^{-3}. The maximum and minimum values of cone index were 0.0432 and 0.1825 kg mm^{-2} with average value of 0.0962 kg mm^{-2}.

KEYWORDS: ***mechanize the weeding operation, pulling force of the weeds, controlling the weeds competing, weed flora, weed intensity, time of weeding and efficiency of workers, physical properties of soil***

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INTRODUCTION

Weeding is an important operation to be carried out during the initial stages of crop growth, especially, for controlling the weeds competing with the crop, stirring the soil for aerating the crop root zones and for burying the weeds into the soil. Weeding operation requires high labour input. In the present scenario, the shortage in labour availability results in operations, ultimately leading to loss of crop yield.

Methods of Weeding

Manual weeding requires large labour force. Labour requirement for weeding depends on weed flora, weed intensity, time of weeding and efficiency of workers. Often several weeding operations are necessary to keep the crop weed free. It is estimated that one-third to one-half of the labour used in crop production is for weed control with an average figure of 30 to 40 man-days/ ha and 8 to 10 man-h/ day (Gupta and Pandey, 1996). Though manual weeding is considered to be the best, the undependable labour availability and escalating wages have given impetus to the

development of mechanical weeding tools and machines.

Herbicides are important in weed control methods (Johnson *et al.,* 2004). Use of herbicides is economically attractive, as it requires less overall weeding time and it enables the farmer to use time and labour saving planting methods such as direct seeding. In India, farmers generally have limited access to information, literacy rates are low and the knowledge of proper herbicide use is often inadequate. Due to this, herbicide applications are late, poorly applied or the application rates are incorrect, resulting in inefficient weed control, increased costs and phytotoxicity damage to the crop.

Mechanical weeding method controls the weeds by physical damage, such as cutting leaves and roots, bruising stems and leaves, covering plants by soil or by uprooting them. Mechanical weeding is preferred considering the fact that manual weeding is time consuming, tedious and costly. Mechanical weeding is done in dry lands by long handled star weeders and rotary type weeders. Manually operated weeders have found acceptability due to their low cost (Behera *et al*., 2007). Mechanical weeders loosen the soil around seedlings, improve the physical properties of soil and reduce environmental pollution compared to chemical weed control method. Mechanical weed control is an effective approach to replace chemical and manual weed control (Jinwu *et al*., 2014).

MATERIAL AND METHODS

Agronomic parameters and soil parameters are essential in deciding the workability of walk behind engine operated weeder in the field. A study was conducted in farmer's field sown with Okra crop at Tondamattur village of Coimbatore district to assess agronomic parameters *viz.,* crop parameters and weed parameters and soil parameters *viz.,* soil moisture content, bulk density and cone index.

Agronomic Parameters

The agronomic parameters are necessary to be considered for weeding operation. Various crop parameters and weed parameters are studied under this section.

Crop Parameters

The important agronomic parameters, which influence the weeding operation, were identified as row spacing and height of the crop.

Row Spacing

The main parameter that influences weeding is row spacing that helps in allowing the tool for operation. Normally, recommended row to row spacing and plant to plant spacing for dry land crops varies between 225 and 900 mm depending on crop varieties (Anon, 1998). Perpendicular distance between two adjacent rows of okra crop was measured using a measuring tape at five random locations and the mean value was found.

Plant Height

Crop height should be such that the machine should not damage the foliage or stems of crops. Moreover, the weeds will compete only at the early stages of crop growth. The height of the crop was measured at five different locations by measuring tape and the mean value was computed.

Weed Parameters

Generally, weeds can be classified into annual weeds and perennial weeds of weed crops (Table1).

Table 1: Types of Weeds (Dedousis, 2007)

S. No.	Type of Weeds	Characteristics
1	Annual weeds	Seed propagation – annual life span
2	Perennial weeds	Root/ bulb propagation – perennial life span

Root Length

Root length decides the weeding depth and power requirement for uprooting the weeds from soil. Ten plants of each type of weeds were selected at random in weed infested filed and uprooted by hand pulling without damaging the roots.

Pulling Force of Weeds

Weed pulling force represents the resistance offered by the roots of the weeds for uprooting, and it depends upon soil moisture, cone index and root length. The force required to pull the weed from the soil was determined using a force gauge (Fig. 1). The maximum force developed at the balance was noted. This was repeated with five more types of weeds and the observations were recorded. The above experiment was carried out at different soil moisture levels and the mean values were tabulated. The pulling force can be correlated as a function of the independent variable as given below.

$$Y = f(X_1, X_2, X_3) \quad (1)$$

Where

Y = Pulling force

X_1 = Soil moisture content

X_2 = Soil cone index

X_3 = Root length

Soil Parameters

The soil parameters influencing the performance of the mechanical weeders were identified as soil moisture, bulk density and cone index.

Soil Moisture

Soil moisture is an important soil parameter that affects the performance of weeders. Carrying out the weeding operation when the soil is too wet causes clod formation and weeds may not be destroyed effectively.

Soil samples were collected at 100 mm depth during harvesting in five different locations at random, and the moisture content on dry basis of the soil was determined by oven method and the mean value was used in the study. The moisture content on dry basis was calculated as

$$MC_{db} = \frac{W_w - W_d}{W_d} \times 100 \quad (2)$$

Where

MC_{db} = soil moisture content, dry basis, %

W_w = weight of the wet sample, g and

W_d = weight of the oven dried sample, g

Soil Bulk Density

Bulk density of the soil is a measure of compactness of the soil. A known volume of undisturbed soil core from the field was collected from ten different places selected at random. The bulk density was calculated as

$$B_{dc} = \frac{W_{tc} - W_c}{V_c} \quad (3)$$

Where

B_{dc} = Bulk density of soil, g cm^{-3}

W_{tc} = Weight of container filled with soil, g

W_c = Weight of empty container, g

V_c = Volume of container, cm^3

Cone Index

Cone index is a measure of penetration resistance of the soil. It affects penetration of weeding tool inside the soil. Cone index was measured at different depths ranging from surface to 100 mm. The cone index was measured using manually operated hand held CPM-84 digital cone penetrometer having a load capacity of 200 kg. The cone used was a B-Type cone with base area of 129 mm^2 and cone apex angle of 30^o (Figure 2). The resistance offered by the soil for the penetration of cone was sensed by the load cell and transmitted to the load indicator and recorder. The recorded data can be transferred to personal computer using data acquisition software and stored as Excel file. The cone index was measured at ten different places selected at random. The cone index was calculated as

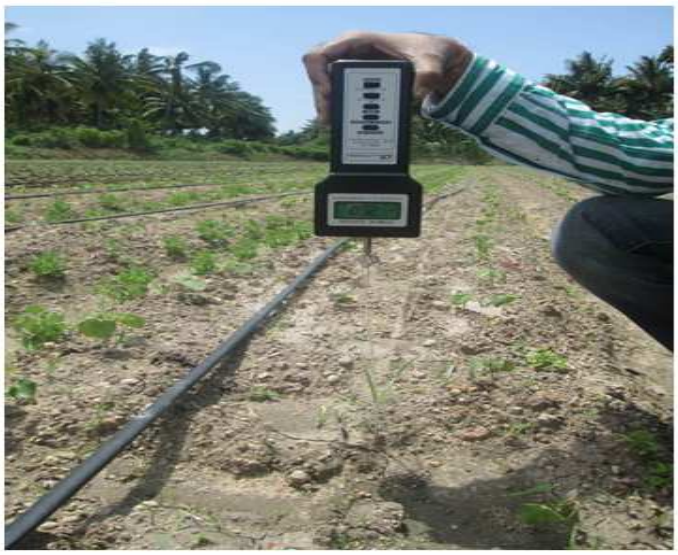

Figure 1: Measurement of Pulling Force of Weeds Using Force Gauge

Figure 2: Cone Penetrometer Used for Measurement of Cone Index

RESULTS AND DISCUSSIONS

Agronomic Parameters

Agronomic parameters *viz.*, crop parameters and weed parameters in okra field were measured and observations were tabulated.

Crop Parameters

Row spacing and plant height of okra crop were measured and observations were recorded

Row Spacing

The row to row spacing of the okra crop was measured on 15 DAS at five places at random in the field and observations are presented in Table 2.

Table 2: Row Spacing of Okra Crop

S. No.	Row Spacing, Mm
1.	370
2.	390
3.	400
4.	360
5.	400
Average	384

Plant Height

The height of the plant was measured at five different locations at random in the field and the readings are furnished in Table 3.

Table 3: Height of the Okra Plants

S. No	Plant Height, Mm
1.	45

2.	50
3.	55
4.	45
5.	50
Average	49

Weed Parameter

The major weeds of different dry land crops were identified. The common major weeds in dry land crops were *Acalypha indica, Echinochloa crus-galli, Echinochloa colona and Trianthema protulacastrum*. The images of the identified weeds are shown in Fig 4.

Root Length

The root lengths of 5 plants in each of the identified weed species were measured. The results were statistically analysed and presented in Table 4. From the table 4, it was observed that the average root length of *Acalypha indica, Echinochloa crus-galli, Echinochloa colona and Trianthema protulacastrum* were 32.4, 40.6, 52.2 and 65.8 mm respectively. In order to uproot the entire weeds from the soil, the weeding depth should be greater than the maximum root length.

Table 4: Root Length of Different Weeds

S. No.	Weed	Root Length, Mm		
		Min.	Max.	Average
1.	*Acalypha indica*	24.9	39.5	32.4
2.	*Echinochloa crus-galli*	37.4	44.7	40.6
3.	*Echinochloa colona*	48.8	59.2	52.2
4.	*Trianthema protulacastrum*	62.8	72.4	65.8

Figure 3: Weeds Identified in Okra Field

Pulling Force of Weeds

The pulling force of the weeds was determined at different locations and tabulated in Table 5.

Multiple Linear Regression Analysis for Pulling Forces

The statistical technique of multiple linear regression analysis was carried out with pulling force of weeds as dependent variable and two soil parameters and a weed parameter as independent variables. The regression statistics was given in Table 6. The results of multiple linear regression analysis were presented in Table 7.

Table 5: Pulling Force of Different Weeds

Weed	Pulling Force, Kgf		
	Min.	Max.	Average
Acalypha indica	0.654	0.955	0.805
Echinochloa crus-galli	0.847	1.225	1.036
Echinochloa colona	2.048	2.225	2.137
Trianthema protulacastrum	2.128	2.305	2.217

From Table 5, it was observed that the average pulling force of different weeds varied from 0.805 to 2.217 kgf.

Table 6: Regression Statistical Analysis of Pulling Force

Parameter	Regression Statistics
Multiple R	0.9795
R Square	0.9595
Adjusted R Square	0.9393
Standard Error	0.2931
Observations	10

Table 7: Correlation Coefficients of Pulling Force

Parameter	Correlation Coefficients
Intercept	80.24*
Soil moisture (X_1)	-0.71*
Cone Index (X_2)	24.11*
Root length (X_3)	0.019 NS

From Table 7, it is found that dependent variable pulling force (Y), for different weeds has a positive relation with cone index (X_2), root length (X_3) and negative relation with moisture content (X_1), which means pulling force increases with increase in cone index and root length, whereas, pulling force decreases with increase in moisture content. Soil moisture (X_1) and Cone index (X_2) are significantly contributing to pulling force (Y) whereas root length (X_3) is not significantly contributing**.**

Soil Parameters

The soil parameters namely, soil moisture, bulk density and cone index were measured and values were tabulated.

Soil Moisture

The moisture content of the soil was determined at different locations at the weeding stage of the crop. Observations were presented in Table 8. From Table 8 it was observed that the average soil moisture was 16.37 per cent (db) and varied from 13 to 23.4 per cent (db).

Table 8: Soil Moisture Content

S. No.	Depth, Mm	Weight Of The Wet Sample (G)	Weight Of The Oven Dried Sample (G)	Soil Moisture Content, Dry Basis (%)

1.	10	113.5	98.2	15.5
2.	20	114.2	100.5	13.6
3.	30	112.9	99.9	13.0
4.	40	111.6	98.4	13.4
5.	50	119.1	100.2	18.8
6.	60	127.4	103.2	23.4
7.	70	121.3	104.5	16.0
8.	80	120.8	102.8	17.5
9.	90	118.3	100.9	17.2
10.	100	114.3	99.1	15.3

Soil Bulk Density

The bulk density of the soil was determined at different locations. The data on soil bulk density is shown in Table 9. It was observed that the bulk density of the soil varied from 1.08 to 1.56 g cm^{-3} with an average value of 1.34 g cm^{-3}

Table 9: Bulk Density of Soil

S. No.	Bulk Density, G Cm^{-3}
1.	1.36
2.	1.41
3.	1.47
4.	1.10
5.	1.56
6.	1.31
7.	1.08
8.	1.23
9.	1.46
10.	1.5

Cone Index

The cone index of the soil was determined at different locations. The values of cone index at ten different locations of the field are presented in Table 10.

Table 10: Cone Index at Different Soil Depths

Location	Cone Index, Kg Mm^{-2} Depth, Mm	
	0 – 50	50 – 100
1	0.0510	0.1436
2	0.0832	0.1825
3	0.0435	0.1138
4	0.0933	0.1721
5	0.0633	0.1534
6	0.0432	0.1269
7	0.0632	0.1125
8	0.0455	0.0957
9	0.0356	0.1270
10	0.0532	0.1210
Average	0.0575	0.1348

The cone index at different locations of the soil is shown in Fig. 4 and Fig. 5. The cone index values increased with increase in depth. The average cone index at 0 to 50 mm depth range was 0.0575 kg mm^{-2} and 0.1348 kg mm^{-2} at 50 to 100 mm depth range. The soil compaction resulting from tractor traffic and other machine intensive cultivation methods

may be the reason for increase in cone index with increase in soil depth.

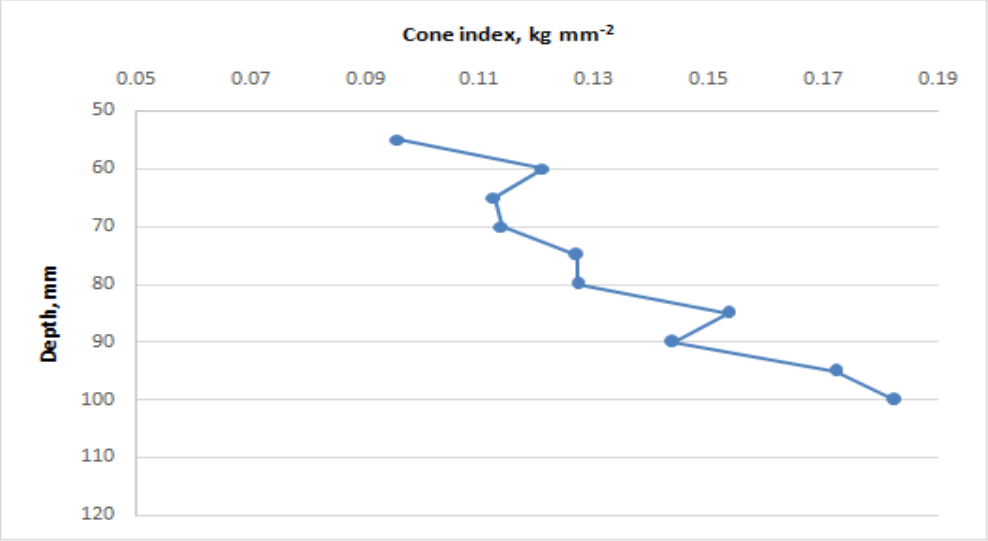

Figure 4: Variation of Cone Index with Soil Depth in 0 To 50 Mm Depth Range

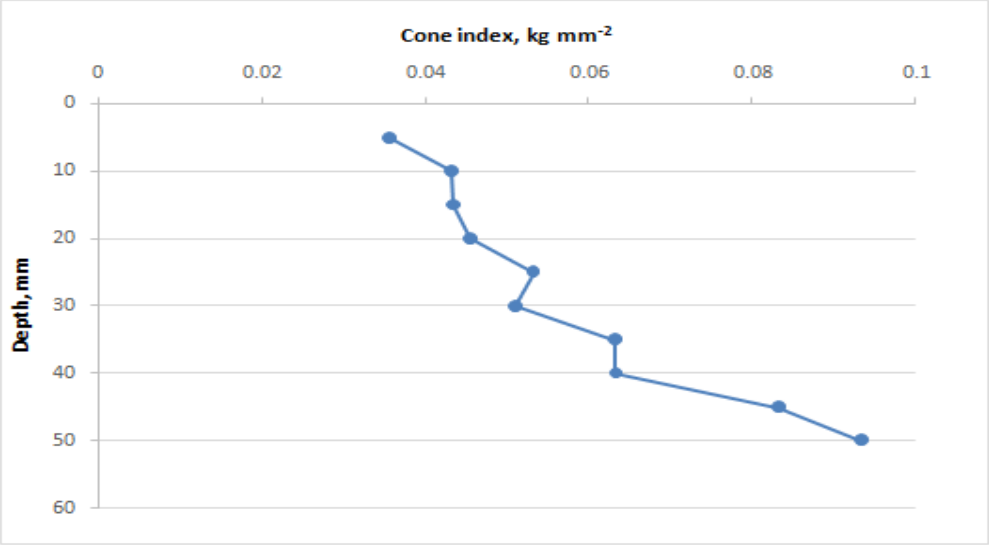

Figure 5: Variation of Cone Index with Soil Depth in 50 To 100 Mm Depth Range

CONCLUSIONS

This study was conducted in farmer's field at Tondamattur village of Coimbatore district, to study agronomic and soil parameters influencing development of walk behind engine operated weeder. Crop parameters and weed parameters such as spacing of crop, plant height, weed root length and puling force of weeds were considered for study under agronomic parameters. Soil parameters *viz.*, soil moisture content, bulk density and cone index were also studied. The spacing of okra crop varied from 360 to 400 mm with an average value of 384 mm. Plant height of okra at15 DAS varied from 45 to 55 mm with an average value of 49 mm. The major weeds identified in the field were *Acalypha indica, Echinochloa crus-galli, Echinochloa ocolona and Trianthema protulacastrum*. The average pulling force of the weeds was

observed to be 0.805, 1.036, 2.137 and 2.217 kgf for the identified weeds respectively. The correlation analysis of pulling force showed that pulling force increases with increase in cone index and root length, whereas, pulling force decreases with increase in moisture content. Moisture content of the soil was in the range 13 to 23.4 per cent (db) with an average value of 16.37 per cent (db). The bulk density of the soil was observed to be in the range of 1.08 to 1.56 g cm^{-3} with an average value of 1.348 g cm^{-3}. The maximum and minimum values of cone index were 0.0432 and 0.1825 kg mm^{-2} with average value of 0.0962 kg mm^{-2}.

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